



# Nature **UNBOUND**

the  
**impact of ecology**  
on Missouri and the World



TEACHER GUIDE

# Forward

*Nature Unbound*, this instructional unit, has been developed to help high school students understand how all the pieces of their science knowledge are inter-related and to demonstrate how to connect those pieces to solve the puzzle of the natural world around them.

This teacher guide includes activities that have been designed to be incorporated into and to satisfy the ecology components of a high school biology course. Ecology Course Level Expectations (CLEs) are assessed in the end of course examination for biology, and this unit provides students with relevant content to address those CLEs.

*Nature Unbound* may also stand alone for high school elective courses in ecology, environmental science or agriculture education and resource management.

Science CLEs are aligned with objectives, content, essential activities and assessment items.

Before you begin, please

- Read through the information in the introductory materials.
- Have students read each chapter before beginning each lesson.
- Adapt activities to suit the needs of your students.

However you decide to incorporate the unit into your science curriculum, the overarching intent of *Nature Unbound* (and of all Discover Nature Schools units) is to lead student learning outdoors and into the natural world—the ultimate laboratory.

## Acknowledgments

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# Teacher Notes

## Discover Nature Schools

Discover Nature Schools (DNS) is a science/conservation education program at its best. Instructional units comprise the backbone of the DNS program and include exciting and engaging hands-on activities designed to bring students in grades K-12 outdoors and closer to nature.

Each unit includes colorful and engaging student books as well as teacher guides with activities designed to meet Missouri Department of Elementary and Secondary Education (DESE) state standards. Grade Level Expectations (GLEs) for elementary and middle school and Course Level Expectations (CLEs) for high school are addressed. DESE at this time has not distinguished biology CLEs specific to ecology. Therefore, the Missouri Department of Conservation has reviewed and assigned those biology CLEs that address ecology for use in this curriculum. Use of science notebooks by students is an important and integrated component.

Lessons guide teachers toward utilizing immediate school grounds (schoolyard ecosystems) as important resources for student learning. At the heart of the DNS program is the belief that the more students equate the outdoors with learning, the more comfortable they become outdoors and the more in tune and familiar they become with outdoor environments. As students become more comfortable and familiar with learning and documenting outdoor experiences, the more they begin to think and act like observant scientists sensitive to and inquisitive about changes in outdoor environments. Many activities in each lesson are designed to be performed outdoors.

Student books and teacher guides (as well as training in their use) are available to all Missouri educators. However, teachers who enroll formally in the DNS program are eligible for additional resources including grant opportunities for field experiences, outdoor classrooms and classroom materials to support specific instructional units.

## Timeline for DNS Units

Middle School—*Conserving Missouri's Aquatic Ecosystems*  
Available since 2007

Elementary School—*Nature Unleashed: The Untamed World of Missouri Ponds, Forests and Prairies*  
Available since 2009

High School—*Nature Unbound: The Impact of Ecology on Missouri and the World*  
Pilot - fall of 2010  
Available fall of 2011

Kindergarten–2nd grade—*See How the Turkey Grows*  
Pilot - fall of 2011  
Available fall of 2012

Early Childhood  
Pilot - fall of 2012  
Available fall of 2013

## Unit Overview

*Nature Unbound: The Impact of Ecology on Missouri and the World (Nature Unbound)* is a unit designed to be taught at the high school level. Ecology CLEs are the primary targets.

*Nature Unbound* does not teach basic biology course concepts but rather builds on the foundation of prior knowledge achieved by students in biology.

Lessons with activities for teaching each chapter in the student book are provided (see “Lesson Components Overview” for more details) as well as alignment to the Missouri State Standards. An alignment piece in the form of a continuum chart is provided to reflect alignment of *Nature Unbound* to Grade Level Expectations (GLEs) in prior learning, Course Level Expectations (CLEs) in targeted learning; and Science College Board Standards for College Success in future learning.

Essential activities should be taught sequentially in order to guide students toward designing a field study or a multi-step plan—gathering, recording and organizing data while outdoors and presenting a report of findings to the class. The Lesson 9 activity incorporates this field study or plan as a culminating activity. This is intended to allow students the chance to demonstrate their ability to think and act like scientists and to provide a key assessment piece for the teacher.

*Nature Unbound* activities are designed to be adapted easily by teachers to meet student needs. Most activities in this unit are designed to get students outdoors and exploring, investigating and asking questions about immediate areas around their school. Science notebooks are integrated into each activity and can play a key role in student learning. By using science notebooks, students model the behavior and investigation methods of scientists. A variety of activities has been included to provide tools to meet diverse learning styles of students and to allow for teaching styles and preferences.

A detailed outline of answers to objectives is included with each lesson for teacher reference. Formative and summative assessments are also provided for each lesson.

A brief “misconception quiz” has been included and should be administered to students before beginning the unit to help identify and address any science concept misconceptions students may have.

Students should take the pre-test at the beginning and again as a post-test at the end of the unit. Pre- and post-test scores are important tools for assessment of student learning and for evaluation of the *Nature Unbound* unit.

## Learning Outdoors

Most activities for *Nature Unbound* lessons are designed to be held outdoors. Tips for providing successful outdoor learning mirror tips for basic, traditional indoor classroom management and learning:

- Establish rules for outdoor experiences.
- Become familiar with the outdoor areas to be used for the unit’s activities.
- Locate and identify for students any poison ivy, thorny brush, etc. to be avoided.
- Ensure that students are aware of their assignment(s) and time limit(s) as well as study/assignment locations, signals for gathering, signals for time, etc.
- Discuss the importance of being prepared for outdoor learning: weather-appropriate attire, insect repellent, sunscreen, etc.
- Provide field guides and/or encourage students to draw detailed pictures and write descriptions “to solve outdoor mysteries” when they return to the classroom.
- Embrace unexpected teachable moments that might “interrupt” an outdoor learning experience.
- Provide time for students to reflect on each outdoor learning experience.
- Share your reflections with your students.

## Unit Time Frame

*Nature Unbound* unit (all lesson activities)—approximately 3 to 4 weeks excluding assessments.

“Estimated Time” section suggests how much time it may take to teach each lesson and activity. Actual time will be affected by the following factors:

- daily schedule of the school
- need for review of previous learning based on the extent of student prior knowledge
- need for reteaching based on the results of formative assessments
- additional resources/knowledge of teacher
- time allotted for group presentations based on class size
- time allotted for cooperative learning activities
- number of activities given as homework rather than completed as class activities
- availability of resources for student use
- number and type of “Extension Activities” and “Optional Activities” used

Lesson Title	Estimated Time
<b>Lesson 1:</b> <b>What is Ecology?</b>	<b>Activities 1.1, 1.2, 1.3</b> —50 minutes
<b>Lesson 2:</b> <b>Reproduction and Adaptation</b>	<b>Activities 2.1, 2.2, 2.3</b> —50 minutes
<b>Lesson 3:</b> <b>Population Checks and Balances</b>	<b>Activities 3.1, 3.2, 3.3</b> —50 minutes
<b>Lesson 4:</b> <b>Interactions—Costs and Benefits of Survival</b>	<b>Activities 4.1, 4.2</b> —50 minutes
<b>Lesson 5:</b> <b>Extinction—Causes and Consequences</b>	<b>Activities 5.1, 5.2</b> —50 minutes
<b>Lesson 6:</b> <b>Exploring the Nature of Energy Flow</b>	<b>Activities 6.1, 6.2</b> —50 minutes
<b>Lesson 7:</b> <b>The Cycling of Elements Through Ecosystems</b>	<b>Activities 7.1, 7.2</b> —50 minutes
<b>Lesson 8:</b> <b>Diversity and Disturbance of Biological Communities</b>	<b>Activities 8.1, 8.2, 8.3</b> —50 minutes
<b>Lesson 9: Culminating Activity—</b> <b>Researching and Planning Like a Resource Manager</b>	Minimum of (2) 50-minute class periods and 1 day for a field experience

## Lessons

A lesson is defined as a logical grouping of information to be taught. Individual lessons will most likely be taught over several days. A lesson in this teacher guide does not necessarily equate to a daily lesson plan. Lessons correspond to chapters in the student book. Lesson 1 in the teacher guide corresponds to Chapter 1 in the student book.

## Lesson Components

**Estimated Time**—Estimated time for each lesson indicates the approximate time to teach the Essential Activities of the lesson. Estimated time for each activity **does not** include time for student reading of the chapter and may be adjusted for class discussions and outdoor research.

**Science CLEs**—Only CLEs specifically addressed in each lesson are listed. Any portion of a CLE not addressed will have a line drawn through it.

**Vocabulary**—Vocabulary listed in each lesson reflect terms bolded in the corresponding chapter in the student book. These are key terms that students must master to fully comprehend the concepts being addressed. These terms are listed in the CLEs and will be assessed. They are defined in the student book text and glossary.

**Lesson Objectives**—Objectives addressed in the lesson are listed.

**Resource Management Objectives**—Objectives addressed in the lesson are listed.

**Essential Questions for the Lesson**—Essential questions are provided to guide students toward field investigations that have the potential to provide rigorous and engaging inquiry experiences. Essential questions may be used to set the stage for the lesson. They may be listed on a bulletin board, blackboard, whiteboard, etc. and are intended to help students think and address questions and ideas as scientists.

**Teacher Notes**—This section provides information to help teachers prepare for the lesson. It may contain additional content information, notes or comments about the lesson, any necessary advanced preparation as well as suggested references for background information.

**Outline of Answers to Objectives**—Content addressed by each objective has been outlined and included in each lesson. Page numbers included at the end of each objective refer to the relevant pages in the student book.

**Essential Activities**—Most lessons have at least two Essential Activities. These activities address and help meet lesson objectives and CLEs listed for each activity.

Essential Activities include:

- Estimated time
- Objectives
- Teacher preparation
- Materials
- Procedure
- Wrap up
- Assessment

**Extension Activities**—Extension activities are either optional portions of an Essential Activity or follow-up activities to an Essential Activity. Extension Activities enhance the Essential Activities but are not required to meet the lesson objectives.

**Optional Activities**—Optional activities do not necessarily enhance specific activities nor are they required to meet lesson objectives. They do provide opportunities for further study related to the lesson. They may also provide an alternative way to teach one of the essential activities. If there are no optional activities for the lesson, this section heading will not be listed.



**Summary**—This is the “Big Ideas” list provided at the beginning of the corresponding chapter in the student book.

**End of Chapter Assessment**—This section provides an opportunity for teachers to evaluate and adjust/revisit their instruction through assessment of student learning (i.e., what needs to be re-taught before moving on to the next lesson). Some or all of the items may be used in different ways depending on teacher preference and student needs. An answer key with possible points for each item is provided.

Examples of some ways to use an End of Chapter Assessment:

- **Advanced Organizer**—Students complete required items as they read the corresponding chapter. These are reviewed to determine student learning and understanding or are referenced during discussions and revised by students as needed.
- **Cooperative Learning**—Incorporate items into group discussions.
- **Worksheet**—Items used as in-class activity/activities or as homework when appropriate. Answer key may be used to grade responses.
- **Quiz**—All or part graded after completing all Essential Activities.

## Student Science Notebooks

Science notebooks are an extremely useful tool for students and teachers alike. They promote good data collection and record-keeping habits and provide reference tools for students. For teachers, they provide ample opportunity for assessment of student work and data organization.

An excerpt from *Using Science Notebooks in Elementary Classrooms* by Michael P. Klentschy published in *NSTA Reports* (monthly newspaper of the National Science Teachers Association), September 2008, Volume 20, Number 1, has been reprinted and included below with permission of NSTA. This excerpt provides useful information on different approaches to and support for the use of science notebooks.

Klentschy (2008) states in the excerpt cited above that “scientists keep notebooks; students should do likewise. Scientists’ notebooks include what worked and what did not work in the investigation. They sometimes learn much more from what did not work.”

Activities in this teacher guide encourage students:

1. To develop their own methods of collecting, recording and presenting data from investigations and long-term observations
2. To share, compare and discuss their methods and findings with other students
3. To re-evaluate their methods, discuss whether or not their investigation was a “fair test” and discuss possible alternatives to their methods
4. To maintain permanent records of all their discussions, observations, data recording methods, etc.
5. To create testable questions, hypotheses and experiments or field research studies

In this way, students are provided “with the opportunity to use science notebooks in much the same way scientists do” and students begin to recognize science notebooks as useful resources for future studies whether the methods used were successful or not.

Science notebooks are important to use with most of the activities found in *Nature Unbound*. Students should record the basic information suggested in the science notebook headings on each outdoor (field) excursion. Abiotic factors such as weather and temperature will affect what they see. As students gather data throughout this unit, they should compare these field notes and draw correlations between abiotic and biotic factors. The data collection sheets supplied with some activities may be attached to the appropriate blank page in a science notebook.

Heading information may vary, but the following basic information should be included for each activity heading. Repetition of this process will reinforce good record-keeping and data collection techniques useful to students throughout their school experiences as well as their lives.

## Science Notebook Headings

**Title**

**Date**

**Time**

**Location**

**Air temperature** (recorded outside)

**Weather conditions\*** (recorded outside)

**Rainfall**

\* Weather conditions include cloud cover, wind speed and direction, humidity, etc. Students may collect information via the Web (<http://www.noaa.gov>). Collection of this weather-related data over time provides students the opportunity to correlate weather and weather patterns to organisms and organism behavior. Students should write summaries of such correlations and draw conclusions. How does weather affect animal behavior? How does it affect migration? How are plants affected by the weather?

Klentschy, M.P., *Using Science Notebooks in Middle School Classrooms*, NSTA Press (Arlington, Virginia), 2010

## Additional Resources

Britsch, Susan and Daniel P. Shepardson. "The Art of Reviewing Science Journals." *Science and Children*, Nov–Dec 2004. pp. 43–45

Campbell, Brian and Lori Fulton. *Science Notebook: Writing About Inquiry*. Portsmouth, NH: Heinemann. 2003

Campbell, Brian and Lori Fulton, "Student-Centered Notebooks." *Science and Children*, Nov-Dec 2004. pp. 26-29

Calhoun, Jeri and Ellen Mintz. "Project Notebook." *Science and Children*, Nov-Dec 2004. pp. 30-34

Leslie, Clare Walker and Charles E. Roth. *Nature Journaling*. Vermont: Storey Books. 1998

Moriarty, Robin, Jeff Winokur and Karen Worth. "Capitalizing on Literacy Connections." *Science and Children*, Feb 2004. pp. 35-39

## Body of the Notebook

Many of the activities start with a question and/or ask the students to develop a question. What students record in their science notebooks may vary according to topic but should include:

- **Record of observations** including labeled sketches
- **Data collection**—Provided data sheets should be incorporated into science notebooks. Encourage students to create their own graphic organizers (data tables, classifying charts, claim and evidence charts, etc.) in their notebooks.
- **Conclusion and/or Summary**—Summarized information collected and answers to questions provided or questions created by students.
- **Reflection**—Reflections on the process, recorded and shared.
  - Were there other ways to collect the data?
  - Were there tools that might have been better to use?
  - What other way(s) could the investigation or experiment have been conducted?
  - What other questions could/should have been asked?
- **Page numbers**—Table of contents and page numbers (to allow reference to previous experiences)

## National Science Teachers Association Article

**Editor's Note:** NSTA Press publishes high-quality resources for science educators. ... The following excerpt comes from *Using Science Notebooks in Elementary Classrooms* by Michael P. Klentschy, edited for publication here. NSTA Press titles are available online through the NSTA Science Store at [www.nsta.org/store](http://www.nsta.org/store).

Student science notebooks are advocated by researchers who believe that writing in science enhances student understanding of science content and process skills. Student science notebooks can be embedded into the science curriculum as a natural part of the goal to assist students in making evidence-based explanations of their science investigations.

The student science notebook is more than a record of data that students collect, facts they learn, and procedures they conduct. It is also a record of students' reflections, questions, predictions, claims linked to evidence, and conclusions, all structured by an investigation leading to an understanding of "big ideas," not just factoids in science. As such, a science notebook is a central place where language, data, and experience work together to form meaning for the student. This form of competence or expertise is developed through active construction of knowledge. Students need time and practice using science notebooks to attain expertise.

Student science notebooks, used well, become an embedded element in the curriculum and thus serve as a ready source of recorded data for both the student and the teacher. They become a direct measure of student understanding of the implemented curriculum and an important means for formative assessment. The science notebooks also reflect an accounting of the progression of an investigation as students formulate and record questions; make predictions; develop a plan of action; record observations, measurements, and data; link claims to evidence; and finally reflect on the investigation. They are the students' personal record that can be referred to and revised throughout an investigation or even an entire unit of study. The science notebooks also serve as the evidence used in group and class discussion.

There are many different approaches to having students create and utilize science notebooks: composition books, blank lab books, lined sheets of paper stapled together or loose-leaf binders.

In primary grades, class or group science notebooks may be created for a unit of study instead of individual student notebooks. Classroom teachers often form covers in the shape of the unit of study, such as a round cover if the students are studying the planets or the Moon. Students as early as kindergarten should be encouraged to keep a record of science investigations. Often these entries will come in the form of scribbles or drawings only decipherable to the student. These form the foundation for later work, when more specific criteria and writing prompts or sentence starters are more formally introduced. The main objective is for teachers to initially provide students with the opportunity to record their science investigation. ...

Scientists keep science notebooks; students should do likewise. Scientists' notebooks include what worked and what did not work in the investigation. They sometimes learn much more from what did not work. These notebooks include data, drawings, charts, and reflections, as well as new questions. Scientist entries are a record of what was learned at the time of the investigation and are not crossed out or erased when new discoveries take place. Newer ideas, thoughts, and reflections are added as new entries. Classroom teachers should adjust their teaching to provide students with the opportunity to use science notebooks in much the same way scientists do.

### Citations [from full article]

- Amaral, O., L. Garrison, and M. Klentschy. 2002. Helping English learners increase achievement through inquiry-based science instruction. *Bilingual Research Journal* 26 (2): 213–239.
- Campbell, B. and L. Fulton. 2003. *Science notebooks*. Portsmouth, NH: Heinemann.
- Klentschy, M., and E. Molina-de la Torre. 2004. *Students' science notebooks and the inquiry process*. In *Crossing borders in literacy and science instruction: Perspectives on theory and practice*, ed. W. Saul, 340–354. Newark, DE: International Reading Association.
- Klentschy, M. P., *Using Science Notebooks in Elementary Classrooms*, NSTA Press (Arlington, Virginia), 2008

- Rivard, L., and S. Straw. 2000. *The effect of talk and writing on learning science: An exploratory study*. Science Education 84 (5): 566–593.
- Shepardson, D., and S. Britsch. 2001. *The role of children's journals in elementary school science activities*. Journal of Research in Science Teaching 38 (1): 43–69.

#### Credit

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## Field Investigations

Use of science notebooks and field investigation techniques by students are integrated components of the *Nature Unbound* unit. The following excerpt from *Field Investigations: Using Outdoor Environments to Foster Student Learning of Scientific Processes* developed for the Association of Fish and Wildlife Agencies' North American Conservation Education Strategy and developed by the Pacific Education Institute is included here to provide teachers with background information on the importance of field investigations and how it relates to student learning.

Field investigations help students become **systems thinkers**, learn the skills of scientific inquiry, and understand that science **doesn't only happen in a laboratory or classroom**. Outdoor experiences in natural settings increase students' problem solving abilities and motivation to learn in social studies, science, language arts and math.

When planning and conducting field investigations, students and scientists grapple with the difficulties of working in a natural system and at the same time develop an understanding of its complexities and subsystems. Systems-thinking involves thinking about relationships, rather than about individual objects. A system can be defined in a number of ways:

- An assemblage of inter-related parts or conditions through which matter, energy, and information flow.
- An organized group of related objects or components that form a whole.
- A collection of things and processes (and often people) that interact to perform some function. The scientific idea of a system implies detailed attention to inputs and outputs and interactions among the system components.

State and national science education standards encourage instruction that focuses on problem-solving and inquiry—activities which characterize the pursuits of scientists. In field investigations, students pose a research question then plan and conduct an investigation to answer that question. Students use evidence to support explanations and build models, as well as to pose new questions about the environment. Students learn that the scientific method is not a simple linear process and, most importantly, experience the difficulty of answering essential questions such as:

- What defines my environment?
- What are all the parts and interrelationships in this ecosystem?
- What is a healthy environment?
- What is humans' relationship to the environment?
- How has human behavior influenced our environment?
- How can our community sustain our environment?
- What is my role in the preservation and use of environmental resources?

Field investigations help students become informed citizen scientists who add knowledge to the community's understanding of an area in order to make issues of concern visible and share differing points of view about the preservation and use of community natural resources.

Classroom science often overemphasizes experimental investigation in which students actively manipulate variables and control conditions. In studying the natural world, it is difficult to actively manipulate variables and maintain "control" and "experimental" groups, so field investigation scientists look for descriptive, comparative, or correlative trends in naturally occurring events. Many field investigations begin with counts (gathering baseline data). Later, measurements are intentionally taken in different locations (Ex. urban and rural, or where some natural phenomenon has created different plot conditions), because scientists suspect they will find a difference. In contrast, in controlled experiments, scientists begin with a hypothesis about links between variables in a system. Variables of interest are identified, and a "fair test" is designed in which variables are

actively manipulated, controlled, and measured in an effort to gather evidence to support or refute a causal relationship.

For conceptual clarity, we have identified three types of field investigations—descriptive, comparative, and correlative.

Descriptive field investigations involve describing and/or quantifying parts of a natural system.	Comparative field investigations involve collecting data on different populations/organisms or under different conditions (Ex: times of year, locations) to make a comparison.	Correlative field investigations involve measuring or observing two variables and searching for a relationship.
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Each type of field investigation is guided by different types of investigative questions. Descriptive studies can lead to comparative studies, which can lead to correlative studies. These three types of studies are often used in combination to study the natural world.

Ryken, A. E., Otto, P., Pritchard, K., & Owens, K. (2007). *Field Investigations: Using Outdoor Environments to Foster Student Learning of Scientific Processes*. Pacific Educational Institute.

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## Collection of Organisms

Not all organisms need to be captured. Many organisms, including insects, may be identified by recording observations in the field and using field guides, Internet, etc. in the classroom. If it is necessary to capture an organism for identification and/or observation, release it where it was captured. Obtain permission to collect specimens whether collecting them from the schoolyard ecosystem or other sites. Collection permits may be required. Some areas, including state conservation areas, require a wildlife collector's permit even if captured specimens are to be released unharmed.

## Assessment Strategies

Several different assessment strategies are available at the end of each lesson to help determine whether students have grasped and fully understand the concepts addressed in the objectives. Both formative and summative assessment items are provided.



# Alignment to Missouri Standards

## Missouri Science Concepts (Strands 1-6) addressed:

- ME.1.I.a** Compare the mass of the reactants to the mass of the products in a chemical reaction of physical change (e.g., biochemical processes, carbon dioxide-oxygen cycle, nitrogen cycle, decomposition and synthesis reactions involved in a food web) as support for the Law of Conservation of Mass
- ME.2.A** Forms of energy have a source, a means of transfer (work and heat), and a receiver
- ME.2.F.a** Classify the different ways to store energy (i.e., chemical, nuclear, thermal, mechanical, electromagnetic) and describe the transfer of energy as it changes from kinetic to potential, while the total amount of energy remains constant, within a system (e.g., biochemical processes, carbon dioxide-oxygen cycle, nitrogen cycle, food web)
- LO.3.A.a** Distinguish between asexual (i.e., binary fission, budding, ~~cloning~~) and sexual reproduction
- LO.3.D** There is heritable variation within every species of organism
- LO.3.D.a** Describe the advantages and disadvantages of asexual and sexual reproduction with regard to variation within a population
- LO.3.D.c** Recognize that new heritable characteristics can only result from new combinations of existing genes or from mutations of genes in an organism's sex cells
- EC.1.A** All populations living together within a community interact with one another and with their environment in order to survive and maintain a balanced ecosystem
- EC.1.A.a** Explain the nature of interactions between organisms in predator/prey relationships and different symbiotic relationships (i.e., mutualism, commensalism, parasitism)
- EC.1.A.b** Explain how cooperative (e.g., symbiotic) and competitive (e.g., predator/prey) relationships help maintain balance within an ecosystem
- EC.1.A.c** Explain why no two species can occupy the same niche in a community (The functional role of a species is not limited to its placement along a food pyramid; it also includes the interactions of a species with other organisms while obtaining food. For example, the methods used to tolerate the physical factors of its environment, such as climate, water, nutrients, soils, and parasites, are all part of its functional role. In other words, the ecological niche of an organism is its natural history: all the interactions and interrelationships of the species with other organisms and the environment.)
- EC.1.B.a** Identify and explain the limiting factors (biotic and abiotic) that may affect the carrying capacity of a population within an ecosystem
- EC.1.B.b** Predict how populations within an ecosystem may change in number and/or structure in response to hypothesized changes in biotic and/or abiotic factors
- EC.1.C.a** Devise a multi-step plan to restore the stability and/or biodiversity of an ecosystem when given a scenario describing the possible adverse effects of human interactions with that ecosystem (e.g., destruction caused by direct harvesting, pollution, atmospheric changes)

- EC.1.C.b** Predict and explain how natural or human caused changes (biological, chemical and/or physical) in one ecosystem may affect other ecosystems due to natural mechanisms (e.g., global wind patterns, water cycle, ocean currents)
- EC.1.D.a** Predict the impact (beneficial or harmful) a natural or human caused environmental event (e.g., forest fire, flood, ~~volcanic eruption, avalanche~~, acid rain, global warming, pollution, deforestation, introduction of an exotic species) may have on the diversity of different species in an ecosystem
- EC.1.D.b** Describe possible causes of extinction of a population
- EC.2.A** As energy flows through the ecosystem, all organisms capture a portion of that energy and transform it to a form they can use
- EC.2.A.a** Illustrate and describe the flow of energy within a food web
- EC.2.A.b** Explain why there are generally more producers than consumers in an energy pyramid
- EC.2.A.c** Predict how the use and flow of energy will be altered due to changes in a food web
- EC.2.B.a** Explain the processes involved in the recycling of nitrogen, oxygen, and carbon through an ecosystem
- EC.2.B.b** Explain the importance of the recycling of nitrogen, oxygen, and carbon within an ecosystem
- EC.3.C** Natural selection is the process of sorting individuals based on their ability to survive and reproduce within their ecosystem
- EC.3.C.a** Identify examples of adaptations that may have resulted from variations favored by natural selection (e.g., ~~long-necked giraffes, long-eared jack rabbits~~) and describe how that variation may have provided populations an advantage for survival
- EC.3.C.b** Explain how genetic homogeneity may cause a population to be more susceptible to extinction (e.g., succumbing to a disease for which there is no natural resistance)
- EC.3.C.c** Explain how environmental factors (e.g., habitat loss, climate change, pollution, introduction of non-native species) can be agents of natural selection
- EC.3.C.d** Given a scenario describing an environmental change, hypothesize why a given species was unable to survive



## Alignment to Missouri Show-Me Goals and Performance Standards:

- 1.1** Develop questions and ideas to initiate and refine research  
(Activities: all)
- 1.2** Conduct research to answer questions and evaluate information and ideas  
(Activities: 5.2, 8.2)
- 1.3** Design and conduct field and laboratory investigations to study nature and society  
(Activities: 1.1, 1.3, 7.2, 8.3, 9)
- 1.5** Comprehend and evaluate written, visual, and oral presentations and works  
(Activities: 4.1)
- 1.6** Discover and evaluate patterns and relationships in information, ideas and structures  
(Activities: 1.2, 2.1)
- 1.8** Organize data, information and ideas into useful forms (including charts, graphs, outlines) for analysis and presentation  
(Activities: 2.3, 6.1, 6.2)
- 1.10** Apply acquired information, ideas and skills to different contexts as students, workers, citizens and consumers  
(Activities: 2.2, 3.1, 3.2, 3.3, 4.2, 7.1)
- 3.2** Develop and apply strategies based on ways others have prevented or solved problems  
(Activities: 5.1)
- 3.5** Reason inductively from a set of specific facts and deductively from general premises  
(Activities: 8.1)

## Alignment to Missouri Show-Me Goals and Content Standards:

- SC1** Properties and principles of matter and energy  
(Lessons: 6, 7)
- SC3** Characteristics and interactions of living organisms  
(Lessons: 2)
- SC4** Changes in ecosystems and interactions of organisms with their environments  
(Lessons: 1, 2, 3, 4, 5, 6, 7, 8, 9)
- SC7** Processes of scientific inquiry (such as formulating and testing hypotheses)  
(Lessons: 1, 2, 3, 4, 5, 6, 7, 8, 9)
- SC8** Impact of science, technology and human activity on resources and the environment  
(Lessons: 1)

## Alignment to Mathematics CLEs:

**N.1.B.A.2** Use real numbers and various models, drawings, etc. to solve problems

**N.3.E.A.2** Solve problems involving proportions

**A.2.C.A.2** Use and solve equivalent forms of equations (linear, absolute value and quadratic) and inequalities

## Alignment to Communication Arts CLEs:

**R3C2** Use details from informational and persuasive text(s) to

- analyze and evaluate the organizational patterns
- identify and analyze faulty reasoning and unfounded inferences
- evaluate proposed solutions
- evaluate for accuracy and adequacy of evidence
- evaluate effect of tone on the overall meaning of work
- analyze and evaluate point of view
- analyze and evaluate author's viewpoint/perspective
- demonstrate comprehension skills previously introduced

**R3D2** Read and apply multi-step directions to perform complex procedures and/or tasks

**W2B2** Compose text with

- strong controlling idea
- relevant specific details
- complex ideas
- freshness of thought

**W3A2** Compose a variety of texts

- using narrative, descriptive expository, and/or persuasive features.
- in various formats, including workplace communication
- including summary
- including literary analysis
- including reflective writing

**LS2A** In discussions and presentations,

- create concise presentations on a variety of topics
- incorporate appropriate media or technology
- respond to feedback
- defend ideas
- demonstrate poise and self-control

**LS2B** Give clear and concise multi-step oral directions to perform complex procedures and/or tasks

**IL1A** Develop an appropriate research plan to guide investigation and research of focus questions

**IL1C** Record relevant information from multiple primary and secondary sources using a self-selected note-taking or organizational strategy

# Science Course Level Expectations Alignment

In this unit, students develop the Science Course Level Expectations (CLEs) listed in the Targeted Learning column below. While supporting students in the development of these skills, teachers should consider students' prior learning and keep in mind their future learning. The CLEs listed in the Targeted Learning column may be addressed in more than one lesson. In the Lesson column, the lesson number(s) are listed followed by which CLE or which portion of a CLE is covered by the lesson. The Depth of Knowledge (DOK) coding indicated in the row directly below the CLE is from the Missouri Department of Elementary and Secondary Education (DESE).

The CLE number coding is in the format used by DESE. The first two letters refer to the strand. (ME=Matter and Energy, LO=Living Organisms, EC=Ecology, IN=Inquiry, ST=Impact of Science, Technology and Human Activity). The first number refers to the "Big Idea" number under the strand. Next, the single uppercase letter refers to the "Concept" under the Big Idea. The lower case letter refers to the specific CLE. See example below:

LO.3.A.a=LO (Living Organisms). 3. There is a genetic basis for the transfer of biological characteristics from one generation to the next through reproductive processes. A. Reproduction can occur asexually or sexually. a. Distinguish between asexual (i.e., binary fission, budding, cloning) and sexual reproduction.

The first column lists the CLEs that align to the lessons and the assessments for each lesson. Not all the CLEs in the first column are used in the activities but all are found in the reading material for the lesson and/or in the Assessment.

The second column aligns the pre/post test and summative assessments at the end of each lesson. CR2 DOK3 1.1 CR=Constructive Response (Other question types would include: MC=Multiple Choice; PE=Performance Event; T/F=True and False; Match=Matching); 2=question number in assessment; DOK=Depth of Knowledge level of question; Goals and Standards "Blue Placemat" ex. 1.1=Develop questions and ideas to initiate and refine research.

Future learning has been extracted from "Science College Board Standards for College Success." The "Science College Board of Standards" document can be found on the following website: <http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf>. LS.1.3. states an objective: LS=Life Science; 1.3=Objective code=Objective: 1=Genetic Variation Within Populations .3=Students understand that genetic variation within a population is essential for natural selection. Mutations, as well as random assortment of existing genes, can produce genetic variation in a population. Under the objective you will find the (9-12) grade level and a blue box of statements. The blue box is bulleted. These statements are more precise than the objectives and match specific CLEs. The exact bullet that is in alignment is indicated. This document consists of knowledge from High School Advanced Placement Classes that students need before they enter college.

Lesson 1	Assessment	Prior Learning	Targeted Learning	Future Learning
EC.1.A	CR2 DOK2 1.10 MC7 DOK3 1.6	EC.1.B.6.a DOK2	EC.1.A All populations living together within a community interact with one another and with their environment in order to survive and maintain a balanced ecosystem.	<b>LS.1.3 (9-12) Blue box bullet 1</b> Natural selection can occur only if there is variation in the genetic information between organisms of the same species in a population and variation in the expression of that genetic information as a trait. Genetic variation within a population influences the likelihood that a population will survive and produce offspring.

Lesson 1	Assessment	Prior Learning	Targeted Learning	Future Learning
EC.1.B.a	Pre/Post test: MC3 DOK2 1.10	EC.1.A.6.a DOK2	EC.1.B.a Identify and explain the limiting factors (biotic and abiotic) that may affect the carrying capacity of a population within an ecosystem. DOK2	LS.3.3 (9-12) <b>Blue box bullet 1</b> The number of organisms in ecosystems fluctuates over time as a result of mechanisms such as migration, birth and death. These fluctuations in the size of populations offset the stability of ecosystems in terms of habitat and resource availability.
EC.1.D.a			EC.1.D.a Predict the impact (beneficial or harmful) a natural environmental event (e.g., forest fire, flood, volcanic eruption, avalanche) or human caused change (e.g., acid rain, global warming, pollution, deforestation, introduction of an exotic species) may have on the diversity of different species in an ecosystem.	
IN.1.A.a	CR3 DOK3 1.3		IN.1.A.a Formulate testable questions and hypotheses. DOK 3	
IN.1.A.c	CR6 DOK2 1.6		IN.1.A.c Design and conduct a valid experiment.	
IN.1.B.a	CR4 DOK2 1.3		IN.1.B.a Make qualitative and quantitative observations using the appropriate senses, tools and equipment to gather data (e.g., microscopes, thermometers, analog and digital meters, computers, spring scales, balances, metric rulers, graduated cylinders): DOK2	
IN.1.C.a	MC5 DOK3 1.6		IN.1.C.a Use quantitative and qualitative data as support for reasonable explanations (conclusions). DOK3	
ST.2.B	Pre/Post test: MC2 DOK1 1.10 CR8 DOK2 1.6		ST.2.B Scientific theories are developed based on the body of knowledge that exists at any particular time and must be rigorously questioned and tested for validity.	
ST.3.A	MC9 DOK1 1.10		ST.3.A People, alone or in groups, are always making discoveries about nature and inventing new ways to solve problems and get work done.	

# CLEs Suggested for Ecology Teachers

DESE at this time has not designated CLEs specific to Ecology. Therefore, the Missouri Department of Conservation has identified the CLEs that are relevant to Ecology curriculum. These CLEs are recommended for a basic foundation for Ecology. There are CLEs in this chart that are not included in the *Nature Unbound* unit.

Strand 1: Properties and Principles of Matter and Energy		
<b>ME.1.1.a</b> 1. Changes in properties and states of matter provide evidence of the atomic theory of matter.	<b>I.</b> Mass is conserved during any physical or chemical change.	<b>a.</b> Compare the mass of the reactants to the mass of the products in a chemical reaction or physical change (e.g. biochemical processes, carbon dioxide-oxygen cycle, nitrogen cycle, decomposition and synthesis reactions involved in a food web) as support for the Law of Conservation of Mass. DOK2
<b>ME.2.A</b> 2. Energy has a source, can be stored, and can be transferred but is conserved within a system.	<b>A.</b> Forms of energy have a source, a means of transfer (work and heat), and a receiver	
<b>ME.2.F.a</b> 2. Energy has a source, can be stored, and can be transferred but is conserved within a system.	<b>F.</b> Energy can be transferred within a system as the total amount of energy remains constant (i.e., Law of Conservation).	<b>a.</b> Classify the different ways to store energy (i.e. chemical, nuclear, thermal, mechanical, electromagnetic) and describe the transfer of energy as it changes from kinetic to potential, while the total amount of energy remains constant, within a system (e.g., biochemical processes, carbon dioxide-oxygen cycle, nitrogen cycle, food web). DOK2
Strand 3: Characteristic and Interactions of Living Organisms		
<b>LO.2.B.b</b> 2. Living organisms carry out life processes in order to survive.	<b>B.</b> Photosynthesis and cellular respiration are complementary processes necessary to the survival of most organisms on Earth.	<b>b.</b> Determine what factors affect the processes of photosynthesis and cellular respiration (i.e., light intensity, availability of reactants, temperature). DOK2
<b>LO.2.D.c</b>	<b>D.</b> Cells carry out chemical transformations that use energy for the synthesis or breakdown of organic compounds.	<b>c.</b> Recognize energy is absorbed or released in the breakdown and/or synthesis of organic compounds. DOK1

Strand 3: Characteristic and Interactions of Living Organisms		
<b>LO.3.A.a</b> 3. There is a genetic basis for the transfer of biological characteristics from one generation to the next through reproductive processes.	<b>A.</b> Reproduction can occur asexually or sexually.	<b>a.</b> Distinguish between asexual (i.e., binary fission, budding, cloning) and sexual reproduction. DOK1
<b>LO.3.D.a</b>	<b>D.</b> There is heritable variation within every species of organism.	<b>a.</b> Describe the advantages and disadvantages of asexual and sexual reproduction with regard to variation within a population. DOK2
<b>LO.3.D.c</b>		<b>c.</b> Recognize that new heritable characteristics can only result from new combinations of existing genes or from mutations of genes in an organism's sex cells. DOK1

Strand 4: Changes in Ecosystems and Interactions of Organisms with their Environments		
<b>EC.1.A.a</b> 1. Organisms are interdependent with one another and with their environment.	<b>A.</b> All populations living together within a community interact with one another and with their environment in order to survive and maintain a balanced ecosystem.	<b>a.</b> Explain the nature of interactions between organisms in predator/prey relationships and different symbiotic relationships (i.e., mutualism, commensalisms, parasitism). DOK1
<b>EC.1.A.b</b>		<b>b.</b> Explain how cooperative (e.g., symbiotic) and competitive (e.g., predator/prey) relationships help maintain balance within an ecosystem. DOK2
<b>EC.1.A.c</b>		<b>c.</b> Explain why no two species can occupy the same niche in a community.  (The functional role of a species is not limited to its placement along a food pyramid; it also includes the interactions of a species with other organisms while obtaining food. For example, the methods used to tolerate the physical factors of its environment, such as climate, water, nutrients, soils, and parasites, are all part of its functional role. In other words, the ecological niche of an organism is its natural history: <u>all the interactions and interrelationships of the species with other organisms and the environment.</u> )
<b>EC.1.B.a</b>	<b>B.</b> Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite.	<b>a.</b> Identify and explain the limiting factors (biotic and abiotic) that may affect the carrying capacity of a population within an ecosystem. DOK2
<b>EC.1.B.b</b>		<b>b.</b> Predict how populations within an ecosystem may change in number and/or structure in response to hypothesized changes in biotic and/or abiotic factors. DOK2

<b>Strand 4: Changes in Ecosystems and Interactions of Organisms with their Environments</b>		
<b>EC.1.C.a</b>	C. All organisms, including humans, and their activities cause changes in their environment that affect the ecosystem.	a. Devise a multi-step plan to restore the stability and/or biodiversity of an ecosystem when given a scenario describing the possible adverse effects of human interactions with that ecosystem (e.g., destruction caused by direct harvesting, pollution, atmospheric changes). DOK3 b. Predict and explain how natural or human caused changes (biological, chemical and/or physical) in one ecosystem may affect other ecosystems due to natural mechanisms (e.g., global wind patterns, water cycle, ocean currents). DOK2
<b>EC.1.C.b</b>		a. Predict the impact (beneficial or harmful) a natural or human caused environmental event (e.g., forest fire, flood, volcanic eruption, avalanche, acid rain, global warming, pollution, deforestation, introduction of an exotic species) may have on the diversity of different species in an ecosystem. DOK2 b. Describe possible causes of extinction of a population. DOK1
<b>EC.1.D.a</b>	D. The diversity of species within an ecosystem is affected by changes in the environment, which can be caused by other organisms or outside processes.	
<b>EC.2.A.a</b>	A. As energy flows through the ecosystem, all organisms capture a portion of that energy and transform it to a form they can use	a. Illustrate and describe the flow of energy within a food web. DOK2
<b>EC.2.A.b</b>		b. Explain why there are generally more producers than consumers in an energy pyramid. DOK2
<b>EC.2.A.c</b>		c. Explain why there are generally more producers than consumers in an energy pyramid. DOK2
<b>EC.2.B.a</b>	B. Matter is recycled through an ecosystem.	a. Explain the processes involved in the recycling of nitrogen, oxygen, and carbon through an ecosystem. DOK2
<b>EC.2.B.b</b>		b. Explain the importance of the recycling of nitrogen, oxygen, and carbon within an ecosystem. DOK1
<b>EC.3.C.a</b>	C. Natural selection is the process of sorting individuals based on their ability to survive and reproduce within their ecosystem.	a. Identify examples of adaptations that may have resulted from variations favored by natural selection (e.g., long-necked giraffes, long-eared jackrabbits) and describe how that variation may have provided populations an advantage for survival. DOK2 b. Explain how genetic homogeneity may cause a population to be more susceptible to extinction (e.g., succumbing to a disease for which there is no natural resistance). DOK2
<b>EC.3.C.b</b>		c. Explain how environmental factors (e.g., habitat loss, climate change, pollution, introduction of non-native species) can be agents of natural selection. DOK2
<b>EC.3.C.c</b>		d. Given a scenario describing an environmental change, hypothesize why a given species was unable to survive. DOK2

<b>Strand 7: Scientific Inquiry</b>		
<b>IN.1.A.a</b> 1. Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking.	<b>A.</b> Scientific inquiry includes the ability of students to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation.	<b>a.</b> Formulate testable questions and hypotheses. DOK3
<b>IN.1.A.b</b>		<b>b.</b> Analyzing an experiment, identify the components (i.e., independent variable, dependent variables, control of constants, multiple trials) and explain their importance to the design of a valid experiment. DOK3
<b>IN.1.A.c</b>		<b>c.</b> Design and conduct a valid experiment. DOK4
<b>IN.1.A.d</b>		<b>d.</b> Recognize it is not always possible, for practical or ethical reasons, to control some conditions (e.g., when sampling or testing humans, when observing animal behaviors in nature). DOK2
<b>IN.1.A.g</b>		<b>g.</b> Evaluate the design of an experiment and make suggestions for reasonable improvements. DOK3
<b>IN.1.B.a</b>	<b>B.</b> Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations.	<b>a.</b> Make qualitative and quantitative observations using the appropriate senses, tools and equipment to gather data (e.g., microscopes, thermometers, analog and digital meters, computers, spring scales, balances, metric rulers, graduated cylinders). DOK2
<b>IN.1.B.b</b>		<b>b.</b> Measure length to the nearest millimeter, mass to the nearest gram, volume to the nearest milliliter, force (weight) to the nearest Newton, temperature to the nearest degree Celsius, time to the nearest second. DOK1
<b>IN.1.B.c</b>		<b>c.</b> Determine the appropriate tools and techniques to collect, analyze, and interpret data. DOK2
<b>IN.1.B.d</b>		<b>d.</b> Judge whether measurements and computation of quantities are reasonable. DOK2
<b>IN.1.B.e</b>		<b>e.</b> Calculate the range, average/mean, percent, and ratios for sets of data. DOK1
<b>IN.1.B.f</b>		<b>f.</b> Recognize observation is biased by the experiences and knowledge of the observer (e.g., strong beliefs about what should happen in particular circumstances can prevent the detection of other results). DOK2
<b>IN.1.C.a</b> 1. Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking.	<b>C.</b> Scientific inquiry includes evaluation of explanations (laws/principles, theories/models) in light of evidence (data) and scientific principles (understandings).	<b>a.</b> Use quantitative and qualitative data as support for reasonable explanations (conclusions). DOK3



<b>Strand 7: Scientific Inquiry</b>		
<b>IN.1.C.b</b>		<b>b.</b> Analyze experimental data to determine patterns, relationships, perspectives, and credibility of explanations (e.g., predict/extrapolate data, explain the relationship between the independent and dependent variable). DOK3
<b>IN.1.C.c</b>		<b>c.</b> Identify the possible effects or errors in observations, measurements, and calculations, on the validity and reliability of data and resultant explanations (conclusions). DOK3
<b>IN.1.D.a</b>	<b>D.</b> The nature of science relies upon communication of results and justification of explanations.	<b>a.</b> Communicate the procedures and results of investigations and explanations through: <ul style="list-style-type: none"> <li>• oral presentations</li> <li>• drawings and maps</li> <li>• data tables (allowing for the recording and analysis of data relevant to the experiment such as independent and dependent variables, multiple trials, beginning and ending times or temperatures, derived quantities)</li> <li>• graphs (bar, single, and multiple line)</li> <li>• equations and writings</li> </ul> DOK: 3

<b>Strand 8: Impact of Science, Technology and Human Activity</b>		
<b>ST.1.A.a</b>	<b>A.</b> People of different gender and ethnicity have contributed to scientific discoveries and the invention of technological innovations.	<b>a.</b> Recognize contributions to science are not limited to the work of one particular group, but are made by a diverse group of scientists representing various ethnic and gender groups. DOK1
<b>ST.2.B</b>	<b>B.</b> Scientific theories are developed based on the body of knowledge that exists at any particular time and must be rigorously questioned and tested for validity	
<b>ST.3.A</b>	<b>A.</b> People, alone or in groups, are always making discoveries about nature and inventing new ways to solve problems and get work done.	
<b>1.</b> Historical and cultural perspectives of scientific explanations help to improve understanding of the nature of science and how science knowledge and technology evolve over time.		
<b>2.</b> Historical and cultural perspectives of scientific explanations help to improve understanding of the nature of science and how science knowledge and technology evolve over time		
<b>3.</b> Science and technology affect, and are affected by, society.		

# Misconception Assessment for *Nature Unbound*

## Gathering Prior Knowledge

True	False	Statement about Ecology
		1. Ecologists primarily study and save endangered animals.
		2. Nature is divided into two parts—biotic and abiotic.
		3. The Biosphere is made up of ecosystems, communities and populations.
		4. Ecologists observe ecosystems to collect data and ask questions.
		5. Adaptations of organisms can be observable within a generation.
		6. Reproduction is essential to the survival of individual organisms – not the species as a whole.
		7. Organisms only reproduce sexually.
		8. Missouri doesn't have endangered species.
		9. The growth rate in a population determines the hunting limits in Missouri.
		10. Deer are a keystone species in Missouri.
		11. Half of the energy in a food web passes to the next trophic level.
		12. Organisms intentionally affect changes in body structure.
		13. Dead organisms simply rot away, and their material disappears.
		14. There are more consumers than producers in a food chain.

# Misconception Assessment for *Nature Unbound*

## Answer Sheet

### Gathering Prior Knowledge

True	False	Statement about Ecology
	✓	1. Ecologists primarily study and save endangered animals.
✓		2. Nature is divided into two parts—biotic and abiotic.
✓		3. The Biosphere is made up of ecosystems, communities and populations.
✓		4. Ecologists observe ecosystems to collect data and ask questions.
	✓	5. Adaptations of organisms can be observable within a generation.
	✓	6. Reproduction is essential to the survival of individual organisms – not the species as a whole.
	✓	7. Organisms only reproduce sexually.
	✓	8. Missouri doesn't have endangered species.
	✓	9. The growth rate in a population determines the hunting limits in Missouri.
	✓	10. Deer are a keystone species in Missouri.
	✓	11. Half of the energy in a food web passes to the next trophic level.
	✓	12. Organisms intentionally affect changes in body structure.
	✓	13. Dead organisms simply rot away, and their material disappears.
	✓	14. There are more consumers than producers in a food chain.

# Pre/Post Assessment for *Nature Unbound*

1. Which definition *best* describes ecology?
  - a. Study of biology including cellular processes
  - b. Study of ecologists including the work that they do
  - c. Study of how nature works including both abiotic and biotic factors
  - d. Study of populations including disease within populations
2. Which statement *best* describes conservation's role in society?
  - a. Conservation practices manage resources for the next generations to have and also use
  - b. Conservation educates the public about ways that they can help Missouri animals
  - c. Conservation educates landowners about the best way to manage ponds
  - d. Conservation practices allow for ecologists to study nature
3. Ecologists work by:
  - a. First developing a question and then setting up an experiment
  - b. First developing a question and then looking up the answers in credible sources
  - c. First developing a question and then creating a model
  - d. Both a and b
  - e. Both a and c

Use the following scenario to answer question 4, 5 and 6.

Mead's milkweed is an endangered species in Missouri. It is self-incompatible which means it produces seeds only when pollen from one plant reaches the flower of a different plant. Mead's milkweed can also spread by sprouting stems from a long underground rhizome.

4. Which reproduction strategy does Mead's milkweed utilize?
  - a. Asexual reproduction
  - b. Sexual reproduction
  - c. Both a and b
  - d. Unilateral reproduction
5. The greatest genetic diversity can be found in which colony of Mead's milkweed?
  - a. A colony that is treated with pesticides
  - b. A colony that reproduces by seed and vegetative reproduction
  - c. A colony that is located in Missouri
  - d. A colony that reproduces only by vegetative reproduction
6. Which species would have the best chance of survival?
  - a. A species that has a population of genetically similar individuals
  - b. A species that has a very small population
  - c. A species that has a population of genetically different individuals
  - d. A species that has a very large population

7. What keeps species' populations from exploding? Choose the best answer.
  - a. Abiotic factors
  - b. Biotic factors
  - c. Limiting factors
  - d. Reproductive factors
8. Key measurements of a population that ecologists make are:
  - a. Size, number of predators and carrying capacity
  - b. Size, density and carrying capacity
  - c. Size, density and dispersion
  - d. Size, carrying capacity and dispersion
9. What would happen, over time, if two species occupied the exact same niche?
  - a. One would outcompete the other
  - b. One would kill the other
  - c. One would become dependent on the other
  - d. One would mate with the other
10. Imagine that the large mammalian predators have been eliminated in an area. What would be the impact to the ecosystem over time? Choose the best answer.
  - a. Prey species would increase exponentially
  - b. The balance of the ecosystem would be restored
  - c. The balance of the ecosystem would be upset
  - d. Other species would not be impacted
11. Which combination of characteristics best describes a species most likely to go extinct?
  - a. Small population with a small home range
  - b. Large population with a large home range
  - c. Small population with a large home range
  - d. Large population with a small home range
12. Which of the following is the major factor causing extinction of a species?
  - a. Hunting
  - b. Habitat destruction or fragmentation
  - c. Being hit by a car
  - d. Competition of a non-native species
13. Why are there usually fewer than five levels in an energy pyramid?
  - a. Almost 90% of the energy in the first level is transferred to primary consumers
  - b. Six levels would be too many
  - c. Energy is lost as it is transferred to each trophic level, making less energy available at each higher trophic level
  - d. There are too many top level predators
14. Suppose muskrats living in a marsh are overharvested. How would the flow of energy be altered? Choose the best answer.
  - a. Less dominant wetland plants would not survive.
  - b. The marsh would have greater diversity of herbivores.
  - c. Cattails would dominate the marsh.
  - d. Both a and c

For questions 15-18, match the description with the appropriate abiotic cycle. Answers may be used once, more than once, or not at all.

- a. Water Cycle
  - b. Nitrogen Cycle
  - c. Carbon Cycle
  - d. Phosphorus Cycle
15. Needed for plants to make amino acids and DNA.
16. Transpiration is a process in plants that is part of this cycle.
17. Precipitation → Runoff → Percolation are all processes in this cycle.
18. A large amount of this element is stored as fossil fuels.
19. Which community is more stable?
- a. One with a large biodiversity
  - b. One with a small biodiversity
  - c. One with a large variety of plant species
  - d. One with a mall
20. A tornado cuts a path through the Mark Twain National Forest. The trees in the forest were leveled, creating large swaths of open areas. Which answer best describes the succession stages that would follow this occurrence?
- a. Small trees followed by perennial plants and woody vegetation, followed by larger trees followed by a forest
  - b. Annual plants followed by perennial plants and woody vegetation, followed by small trees, followed by forest
  - c. Small trees followed by larger trees, followed by a forest
  - d. People move in and subdivide the area into housing tracts

# Pre/Post Test Questions and Answers for *Nature Unbound*

1. Which definition *best* describes ecology?
  - a. Study of biology including cellular processes
  - b. Study of ecologists including the work that they do
  - c. Study of how nature works including both abiotic and biotic factors
  - d. Study of populations including disease within populations

**Answer:** c
2. Which statement *best* describes conservation's role in society?
  - a. Conservation practices manage resources for the next generations to have and also use
  - b. Conservation educates the public about ways that they can help Missouri animals
  - c. Conservation educates landowners about the best way to manage ponds
  - d. Conservation practices allow for ecologists to study nature

**Answer:** a
3. Ecologists work by:
  - a. First developing a question and then setting up an experiment
  - b. First developing a question and then looking up the answers in credible sources
  - c. First developing a question and then creating a model
  - d. Both a and b
  - e. Both a and c

**Answer:** e

Use the following scenario to answer question 4,5 and 6.

Mead's milkweed is an endangered species in Missouri. It is self-incompatible which means it produces seeds only when pollen from one plant reaches the flower of a different plant. Mead's milkweed can also spread by sprouting stems from a long underground rhizome.

4. Which reproduction strategy does Mead's milkweed utilize?
  - a. Asexual reproduction
  - b. Sexual reproduction
  - c. Both a and b
  - d. Unilateral reproduction

**Answer:** c
5. The greatest genetic diversity can be found in which colony of Mead's milkweed?
  - a. A colony that is treated with pesticides
  - b. A colony that reproduces by seed and vegetative reproduction
  - c. A colony that is located in Missouri
  - d. A colony that reproduces only by vegetative reproduction

**Answer:** b

6. Which species would have the best chance of survival?
- A species that has a population of genetically similar individuals
  - A species that has a very small population
  - A species that has a population of genetically different individuals
  - A species that has a very large population

**Answer:** c

7. What keeps species' populations from exploding? Choose the best answer.
- Abiotic factors
  - Biotic factors
  - Limiting factors
  - Reproductive factors

**Answer:** c

8. Key measurements of a population that ecologists make are:
- Size, number of predators and carrying capacity
  - Size, density and carrying capacity
  - Size, density and dispersion
  - Size, carrying capacity and dispersion

**Answer:** c

9. What would happen, over time, if two species occupied the exact same niche?
- One would outcompete the other
  - One would kill the other
  - One would become dependent on the other
  - One would mate with the other

**Answer:** a

10. Imagine that the large mammalian predators have been eliminated in an area. What would be the impact to the ecosystem over time: Choose the best answer.
- Prey species would increase exponentially
  - The balance of the ecosystem would be restored
  - The balance of the ecosystem would be upset
  - Other species would not be impacted

**Answer:** c

11. Which combination of characteristics best describes a species most likely to go extinct?
- Small population with a small home range
  - Large population with a large home range
  - Small population with a large home range
  - Large population with a small home range

**Answer:** a

12. Which of the following is the major factor causing extinction of a species?
- Hunting
  - Habitat destruction or fragmentation
  - Being hit by a car
  - Competition of a non-native species

**Answer:** b



13. Why are there usually fewer than five levels in an energy pyramid?
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  - Six levels would be too many
  - Energy is lost as it is transferred to each trophic level, making less energy available at each higher trophic level
  - There are too many top level predators

**Answer:** c

14. Suppose muskrats living in a marsh are overharvested. How would the flow of energy be altered? Choose the best answer.
- Less dominant wetland plants would not survive.
  - The marsh would have greater diversity of herbivores.
  - Cattails would dominate the marsh.
  - Both a and c

**Answer:** d

For question 15 - 18 match the description with the appropriate abiotic cycle. Answers may be used once, more than once, or not at all.

- The Water Cycle
- The Nitrogen Cycle
- The Carbon Cycle
- The Phosphorus Cycle

15. Needed for plants to make amino acids and DNA.

**Answer:** b

16. Transpiration is a process in plants that is part of this cycle.

**Answer:** a

17. Precipitation → Runoff → Percolation are all processes in this cycle.

**Answer:** a

18. A large amount of this element is stored as fossil fuels.

**Answer:** c

19. Which community is more stable?

- One with a large biodiversity
- One with a small biodiversity
- One with a large variety of plant species
- One with a small

**Answer:** a

20. A tornado cuts a path through the Mark Twain National Forest. The trees in the forest were leveled, creating large swaths of open areas. Which answer best describes the succession stages that would follow this occurrence?

- Small trees followed by perennial plants and woody vegetation followed by larger trees followed by a forest.
- Annual plants followed by perennial plants and woody vegetation followed by small trees followed by forest.
- Small trees followed by larger trees, followed by a forest.
- People move in and subdivide the area into housing tracts.

**Answer:** b

# Materials List

Air thermometers  
Biltmore sticks  
Calculators  
Collection jars or other containers for live invertebrates  
Colored markers  
Flagging tape  
Forceps  
Golf tees—100 white, 100 green, 75 blue, 75 red, 25 tan  
Hula hoops/yardsticks/rope  
Insect field guide  
Insect nets  
Magnifiers  
Metric rulers/metric measuring tapes  
Nail polish  
“Odyssey” essay from *Sand County Almanac*, by Aldo Leopold  
Orange cones or tent stakes  
Poster board  
Rolls of adding machine paper or toilet paper  
Rope  
Safety goggles and gloves  
Scissors  
Soil or water test kits or probes for nitrogen and or phosphorus  
(These may be available by loan from a county soil and water conservation agency.)  
Soil thermometers  
Tokens—20 each of three colors  
Tree field guide  
Weather data collection equipment  
(anemometers, sling psychrometers, light meters, Kestrel, etc.)  
Yarn

# Lesson 1: What is Ecology?

## Estimated time

(4) 50-minute class periods

## Science CLEs

- EC.1.A.** All populations living together within a community interact with one another and with their environment in order to survive and maintain a balanced ecosystem
- EC.1.B.a.** Identify and explain the limiting factors (biotic and abiotic) that may affect the carrying capacity of a population within an ecosystem
- IN.1.A.a.** Formulate testable questions and hypotheses
- IN.1.B.a.** Make qualitative and quantitative observations using the appropriate senses, tools and equipment to gather data (e.g., ~~microscopes~~, thermometers, analog and digital meters, computers, ~~spring scales~~, ~~balances~~, metric rulers, ~~graduated cylinders~~)
- IN.1.C.a.** Use quantitative and qualitative data as support for reasonable explanations (conclusions)
- ST.3.A.** People, alone or in groups, are always making discoveries about nature and inventing new ways to solve problems and get work done

## Vocabulary

Biotic	Population size
Abiotic	Community
Atoms	Ecosystem
Molecules	Biosphere
Organelles	Hypothesis
Cells	Independent variable
Tissues	Dependent variable
Organs	Experimental group
Organism	Control group
Population	Natural resource manager

## Objectives

1. Define ecology.
2. Describe the scope of ecology.
3. Illustrate and explain how organism, population, community, ecosystem and biosphere are connected.
4. Explain how ecologists conduct research and give examples of questions ecologists might ask at each level of focus from organism to biosphere.
5. Explain why ecology is important.

## Resource Management Objectives

1. Explain the relationship between resource management and ecology.
2. Define conservation and its importance to society.

## Essential Questions

1. What is ecology and why is it important?
2. How do ecologists organize nature?

## Teacher Notes

Students should read *Nature Unbound* Chapter 1 before beginning Lesson 1 activities.

The area around the school (hereafter referred to as the schoolyard ecosystem) will suffice for activities developed to be taught outdoors. Page 2 of this teacher guide provides brief tips and information on preparing for outdoor activities. Science notebooking is an important component of this unit. Page 4 of this guide provides information on the purpose and process of using science notebooks. It is suggested that you review with your students how to keep a science notebook before starting the *Nature Unbound* unit.

As part of their science notebooks, students will be required to record basic abiotic factors such as weather conditions, temperature, light intensity, humidity, etc. depending on the equipment available. This should be done with every activity. Recording temperature with each activity will allow students to collect data over time and correlate organisms observed to weather conditions. As students collect this data, they can create charts or graphs to organize it. Students should also be encouraged to correlate abiotic data with biotic data. Have students summarize their correlations (ex. How does weather affect the number of animal species observed? How does weather affect animal behavior? How does weather affect plant growth?)

Weather data can be obtained on the Internet at a weather data site and/or taken in the field.

## Outline of Answers to Objectives

See following page.

## Essential Activities

**Essential Activity 1.1**—Schoolyard Ecosystem—Biotic and Abiotic Factors

**Essential Activity 1.2**—Ecology—The Big Picture: Examine the Parts to Make a Whole

**Essential Activity 1.3**—Establishing Study Sites and Collecting Data

## End of Chapter Assessment

Lesson 1 Questions and Answer Key

## Summary

- Ecology is the study of how nature works.
- Ecologists study things as small as individual organisms or as large as the biosphere.
- Ecologists make observations, ask questions and collect data.
- Understanding ecology is important for many reasons.

## Outline of Answers to Objectives

1. **Define ecology.** (*Nature Unbound* p. 4)
  - a. Ecology is the study of how nature works.
    - i. Two basic components:
      1. The biotic (living) part of nature is composed of plants, animals, fungi, protists and bacteria—anything that is alive.
      2. The abiotic (nonliving) part is composed of the physical and chemical components of the environment, including water, sunlight, temperature, oxygen and soil chemistry.
    - ii. Any living thing is affected by and responds to both biotic and abiotic parts of its environment. Likewise, abiotic parts of the environment are affected by living things. Ecologists seek to understand these relationships.
2. **Describe the scope of ecology.** (p. 4)
  - a. Ecologists study things as small as individual organisms or as large as the biosphere.
3. **Illustrate and explain how organism, population, community, ecosystem and biosphere are connected.** (pp. 5-8)
  - a. Ecologists studying an organism (a single living thing) try to learn how living things are affected by and respond to their environment.
  - b. Ecologists studying a population (a group of the same kind of organisms living together in the same place at the same time) try to learn what factors contribute to an increase or decrease in the population's size.
  - c. Ecologists studying communities (groups of different populations living in the same place at the same time) try to figure out how various interactions affect the populations involved.
  - d. Ecologists studying ecosystems (a community along with the abiotic factors of the environment) try to understand how energy is transferred from the sun through different organisms that feed upon each other; how atoms essential for life cycle through both abiotic and biotic parts of the ecosystem; and how physical processes, such as fire or flooding, affect the communities in the ecosystem.
  - e. Ecologists studying the biosphere (the layer of our planet that supports and contains every living thing) try to understand how global processes affect different ecosystems. Ecologists study how things in one ecosystem affect other ecosystems.
4. **Explain how ecologists conduct research and give examples of questions ecologists might ask at each level of focus from organism to biosphere.** (p. 9)
  - a. Ecologists make observations, ask questions and collect data.
    - i. Observations lead to questions.
    - ii. The ecologist then writes a hypothesis to answer the question. A hypothesis contains:
      1. Independent variable (changed or manipulated in some way)
      2. Dependent variable (reacts to changes made to the independent variable)
    - iii. To test the hypothesis, the ecologist collects data using observations, experiments, models or a combination of the three.
    - iv. Then the ecologist analyzes and interprets the data, often using mathematics and statistics to see if it supports or disproves the hypothesis. This often leads to more questions.
    - v. Examples of questions ecologists might ask:
      1. Organism: How does water temperature affect bullfrog behavior?
      2. Population: How many river otters can the Grand River watershed support?
      3. Community: Do red-winged blackbirds and marsh wrens compete for nesting sites?
      4. Ecosystem: How fast does nitrogen move through a wetland ecosystem?
      5. Biosphere: How much carbon do Missouri wetlands remove from Earth's atmosphere?
5. **Explain why ecology is important.** (p. 13)
  - a. Ecological systems provide the life support functions all life needs.
  - b. Ecological systems provide us with an infinite number of products.
  - c. If the Earth's life support systems break down, we need to know how to fix them. Ecology gives us a way to learn how these systems work, recognize when they are failing and provide ideas for fixing problems. Our life depends on it. That is why understanding ecology is important.

## Resource Management Objectives

1. **Explain the relationship between resource management and ecology.** (p. 10)
  - a. Although ecology and resource management are related, they are not the same.
  - b. Ecology is a pure science; resource management is an applied science.
  - c. In the same way that medical doctors apply knowledge learned from anatomy and physiology to maintain and restore the health of their patients, resource managers apply principles learned from ecology to protect, maintain and restore healthy ecosystems.
  
2. **Define conservation and its importance to society.** (p. 12)
  - a. Conservation is a way of using resources that keeps them healthy and intact for use by future generations.
  - b. Because we all depend upon the Earth's ecosystems for food, water, clothing and shelter, it's important to realize that maintaining the harmony between people and land is a responsibility for all of us. Learning about ecology is one way you can gain the knowledge to make wise decisions about how you use natural resources.

# Essential Activity 1.1

## Schoolyard Ecosystem—Biotic and Abiotic Factors

### Estimated time

(1) 50-minute class period

### Objectives

Students will be able to:

1. Identify biotic and abiotic factors.
2. Explain how ecologists conduct research.
3. Create a base line study for future investigations.

### Teacher Preparation

This activity serves as an introduction to going outdoors and using science notebooks, both important elements of this unit. Develop a management plan for conducting activities outdoors with students.

For this activity, a portion of the schoolyard ecosystem (the area within the schoolyard, around or near the school and/or an outdoor classroom) should be divided into study areas using available materials. (Hula hoops work well to set off small areas; sets of four meter sticks can be arranged in a square; rope or string heavy enough not to be disturbed by wind can also be arranged in a circle shape to set off an area.) Students should work in teams to survey assigned study areas. Students should record all abiotic and biotic factors they observe and organize the information themselves or use the charts provided and store them in their science notebooks at the end of the activity.

If students are unfamiliar with data collection techniques, practice inside by setting up “study sites” within the classroom. Place “organisms” such as everyday items from your classroom or outside within these sites. Practice using sampling tools like thermometers to collect and chart data.

### Materials

Student science notebooks

Pencils

Air thermometers

Copies of *1.1 Biotic/Abiotic Chart* (if needed)

Hula hoops, or meter sticks and rope/heavy string, or flagging tape, etc.

### Procedure

1. Review the plan for outside activities with students and separate them into groups of three or four *before* leaving the classroom.
2. Have students prepare their science notebook page by creating the standard headings:
  - a. Title
  - b. Date
  - c. Time
  - d. Location
  - e. Air temperature (recorded outside)
  - f. Weather conditions (recorded outside) such as cloud cover, wind speed and direction, humidity, etc.

3. Have students create a map of the schoolyard ecosystem, or have students use a map program like Google Earth to familiarize themselves with the areas available for study. If space allows, have students set out several study areas and assign at least one group per area.
4. Review definitions of biotic and abiotic factors or use completed student observation charts to assess prior knowledge of these terms.
5. Instruct students to record all abiotic and biotic factors and the number of each within their assigned area. Students should estimate numbers that are too abundant to count individually within a study area (ex. clover flowers > 100; blades of grass > 1000).
6. Provide students sufficient time to survey their area and to record their observations.
7. Instruct students to record two things they were curious about during their observation and write a question for each.
8. While outside:
  - a. Discuss how students might compile their data to lay the groundwork for future investigations.
  - b. Review for accuracy and discuss student entries from the *1.1 Biotic/Abiotic Charts* (check that students included plants and animals as biotic factors):
    1. What factors, if any, were difficult to label as biotic or abiotic?
    2. How did the weather conditions affect what they saw?
    3. What biotic and abiotic factors did they expect to find?
    4. What factors were they surprised to find?
    5. How might a natural area or conservation area manager use the information collected?
  - c. Have students write a short summary of the data collected.
9. Have students retrieve study area materials.
10. Back in the classroom:
  - a. List student questions on the board.
  - b. Have students discuss and define what it means to have a “testable” question.
  - c. Discuss which questions could be made into testable questions.
  - d. Have students write a hypothesis for one of their questions.

## Wrap up

1. Have students discuss the following:
  - a. How did weather conditions affect what they saw?
  - b. Were they surprised to find something in particular?
  - c. Were they surprised not to find something they had expected would be there?
2. Why would someone managing a natural area or conservation area need to know the information collected?

## Assessment

Check student charts for accuracy and completion. Set a minimum number for each factor, biotic and abiotic.



